NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

REPORT No. 338

THE EFFECT OF REDUCTION GEARING ON PROPELLER-BODY INTERFERENCE AS SHOWN BY FULL SCALE WIND TUNNEL TESTS

By FRED E. WEICK

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AERONAUTICAL SYMBOLS

1. FUNDAMENTAL AND DERIVED UNITS

	Symbol	Metric		English	
		Unit	Symbol	Unit	Symbol
Length	l	meter	m	foot (or mile)	ft. (or mi.)
Time	t	second	s	second (or hour)	sec. (or hr.)
Force	F	weight of one kilogram	kg	weight of one pound	lb.
Power	P	kg/m/s		horsepower	hp
Speed		km/hr	k. p. h.	mi./hr.	m. p. h.
		m/s	m. p. s.	ft./sec.	f. p. s.

2. GENERAL SYMBOLS, ETC.

W, Weight, $=mg$

g, Standard acceleration of gravity $=9.80665$ m/s^2 $=32.1740$ ft./sec.^{2}

m, Mass, $=\frac{W}{g}$

ρ, Density (mass per unit volume).

Standard density of dry air, 0.12497 (kg-m^{-4} s^2) at 15° C and 760 mm $=0.002378$ (lb.-ft.$^{-4}$ sec.^{2}).

Specific weight of "standard" air, 1.2255 kg/m^3 $=0.07651$ lb./ft.^{3}

mk^2, Moment of inertia (indicate axis of the radius of gyration, k, by proper subscript).

S, Area.

S_w, Wing area, etc.

G, Gap.

b, Span.

c, Chord length.

b/c, Aspect ratio.

f, Distance from C. G. to elevator hinge.

μ, Coefficient of viscosity.

3. AERODYNAMICAL SYMBOLS

V, True air speed.

q, Dynamic (or impact) pressure $=\frac{1}{2}\rho V^2$

L, Lift, absolute coefficient $C_L=\frac{L}{qS}$

D, Drag, absolute coefficient $C_D=\frac{D}{qS}$

C, Cross-wind force, absolute coefficient $C_C=\frac{C}{qS}$

R, Resultant force. (Note that these coefficients are twice as large as the old coefficients L_C, D_C.)

i_w, Angle of setting of wings (relative to thrust line).

i_t, Angle of stabilizer setting with reference to thrust line.

γ, Dihedral angle.

$\rho\frac{Vl}{\mu}$, Reynolds Number, where l is a linear dimension.

e. g., for a model airfoil 3 in. chord, 100 mi./hr. normal pressure, 0° C: 255,000 and at 15° C., 230,000;

or for a model of 10 cm chord 40 m/s, corresponding numbers are 299,000 and 270,000.

C_p, Center of pressure coefficient (ratio of distance of C. P. from leading edge to chord length).

β, Angle of stabilizer setting with reference to lower wing, $=(i_t-i_w)$.

α, Angle of attack.

ϵ, Angle of downwash.

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NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

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EXECUTIVE COMMITTEE

REPORT No. 338

THE EFFECT OF REDUCTION GEARING ON PROPELLER-BODY INTERFERENCE AS SHOWN BY FULL SCALE WIND TUNNEL TESTS

By Fred E. Weick

SUMMARY

Full-scale tests have been made in the Propeller Research Tunnel of the National Advisory Committee for Aeronautics, on a 10-foot 5-inch propeller on a geared J–5 engine and also on a similar 8-foot 11-inch propeller on a direct-drive J–5 engine. Each propeller was tested at two different pitch settings, and with a large and a small fuselage. The investigation was made in such a manner that the propeller-body interference factors were isolated, and it was found that, considering this interference only, the geared propellers had an appreciable advantage in propulsive efficiency, partially due to the larger diameter of the propellers with respect to the bodies, and partially because the geared propellers were located farther ahead of the engines and bodies.

INTRODUCTION

The question of the desirability of reduction gearing between an aircraft engine and its propeller is involved, because of the many factors which must be considered. Some of these factors are (1) the relative tip speeds and the resultant effect on the propeller efficiency, (2) the loss of power in the gears, (3) the weight of the propeller and gearing, (4) the effect of the limiting propeller diameter or of possible differences in landing-gear height, (5) the effect on the propeller efficiency of change of pitch, and (6) the effect of the propeller-body interference on the propulsive efficiency. This report describes experiments which isolate and give some practical information on the last of these factors, the effect of propeller-body interference.

A standard 10.5-foot aluminum-alloy propeller with detachable and adjustable blades was tested at two pitch settings and on two different bodies (a cabin fuselage and a smaller open cockpit fuselage), with a geared J–5 radial air-cooled engine having conventional cowling. The results are compared with those of tests on geometrically similar direct-drive propellers tested with the same engine and fuselages.

All of the tests were run at medium tip speeds or under, where the effect of tip speed on the aerodynamic coefficients of the form of propeller used has been found to be negligible. (Reference 1.) All of the other factors, excepting the propeller-body interference, have been eliminated.

The tests were made in the Twenty-Foot Propeller Research Tunnel of the National Advisory Committee for Aeronautics, at Langley Field, Va. (Reference 2.)

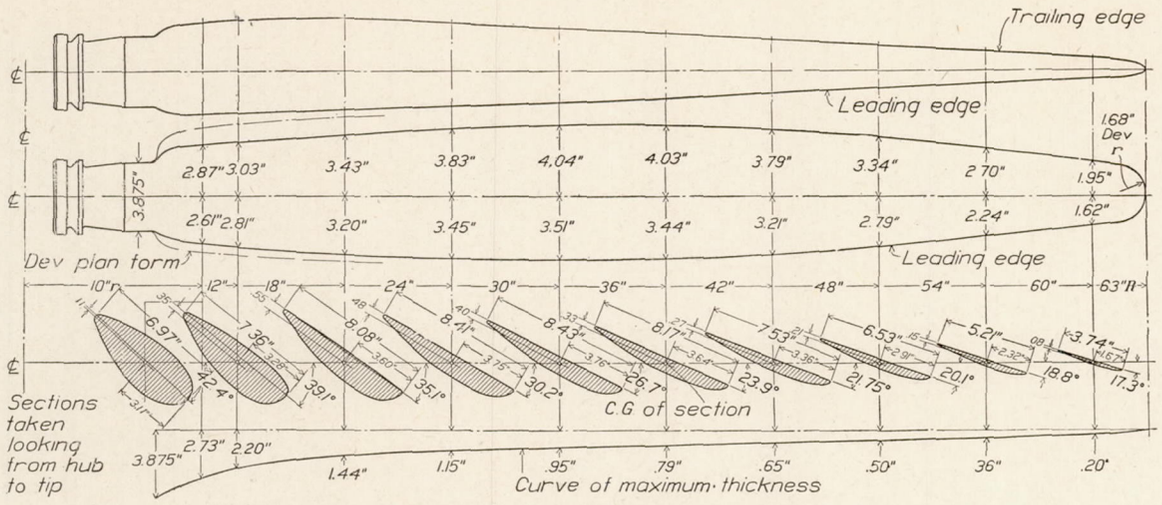

FIGURE 1.—Metal blade 10.5-foot diameter propeller. Right-hand No. 4102

ORDINATES OF SECTIONS AT VARIOUS RADII FOR EXPERIMENTAL METAL PROPELLER BLADE

10.5 FEET DIAMETER, RIGHT-HAND. (FIG. 1)

S	10″ r		12″ r		18″ r		24″ r	30″ r	36″ r	42″ r	48″ r	54″ r	60″ r
	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Upper	Upper	Upper	Upper	Upper	Upper
	Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
2. 5	0. 56	0. 50	0. 62	0. 28	0. 57	0. 03	0. 47	0. 39	0. 32	0. 27	0. 21	0. 15	0. 08
5	. 76	. 73	. 90	. 40	. 81	. 04	. 68	. 56	. 47	. 38	. 30	. 21	. 12
10	1. 03	. 97	1. 20	. 54	1. 09	. 05	. 91	. 75	. 62	. 51	. 40	. 28	. 16
20	1. 34	1. 17	1. 44	. 65	1. 31	. 06	1. 09	. 90	. 75	. 62	. 48	. 34	. 19
30	1. 50	1. 23	1. 52	. 68	1. 38	. 06	1. 15	. 95	. 79	. 65	. 50	. 36	. 20
40	1. 49	1. 22	1. 51	. 67	1. 37	. 06	1. 14	. 94	. 78	. 64	. 50	. 36	. 20
50	1. 43	1. 17	1. 44	. 65	1. 31	. 06	1. 09	. 90	. 75	. 62	. 48	. 34	. 19
60	1. 31	1. 07	1. 32	. 59	1. 20	. 05	1. 00	. 83	. 69	. 57	. 44	. 31	. 17
70	1. 11	. 91	1. 13	. 50	1. 02	. 045	. 85	. 70	. 59	. 48	. 37	. 27	. 15
80	. 84	. 69	. 85	. 38	. 77	. 03	. 64	. 53	. 44	. 36	. 28	. 20	. 11
90	. 53	. 43	. 53	. 24	. 48	. 02	. 40	. 33	. 28	. 23	. 18	. 13	. 07
Rad. T. E.	0. 27		0. 20		0. 11		. 09	. 07	. 06	. 05	. 04	. 03	. 02
Rad. L. E.	1. 00		. 49		. 16		. 12	. 10	. 08	. 07	. 05	. 04	. 02
Chord	6. 97		7. 36		8. 08		8. 41	8. 43	8. 17	7. 53	6. 53	5. 21	3. 74

The chord is divided into 10 equal parts, or stations, with the one at the leading edge subdivided into halves and quarters. S equals stations in per cent of chord from the leading edge.

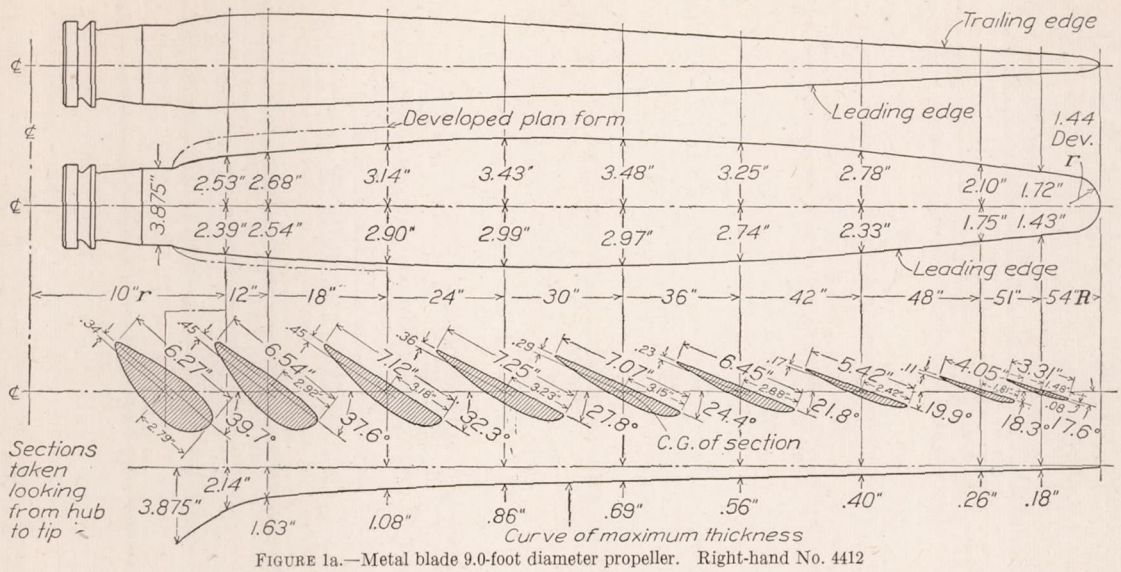

FIGURE 1a.—Metal blade 9.0-foot diameter propeller. Right-hand No. 4412

ORDINATES OF SECTIONS AT VARIOUS RADII FOR EXPERIMENTAL METAL PROPELLER BLADE

9.0 feet diameter, right-hand. (Fig. 1a)

S	10″ r		12″ r		18″ r	24″ r	30″ r	36″ r	42″ r	48″ r	51″ r
	Upper	Lower	Upper	Lower	Upper	Upper	Upper	Upper	Upper	Upper	Upper
	Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
2. 5	0. 61	0. 25	0. 56	0. 11	0. 44	0. 35	0. 28	0. 23	0. 16	0. 11	0. 07
5	. 87	. 39	. 80	. 16	. 64	. 51	. 41	. 33	. 24	. 15	. 11
10	1. 17	. 52	1. 07	. 21	. 85	. 68	. 55	. 44	. 32	. 21	. 14
20	1. 41	. 63	1. 29	. 26	1. 03	. 82	. 66	. 53	. 38	. 25	. 17
30	1. 48	. 66	1. 36	. 27	1. 08	. 86	. 69	. 56	. 40	. 26	. 18
40	1. 47	. 65	1. 35	. 27	1. 07	. 85	. 68	. 56	. 40	. 26	. 18
50	1. 41	. 63	1. 29	. 26	1. 03	. 82	. 66	. 53	. 38	. 25	. 17
60	1. 29	. 57	1. 18	. 24	. 94	. 75	. 60	. 49	. 35	. 23	. 16
70	1. 10	. 49	1. 01	. 20	. 80	. 64	. 51	. 42	. 30	. 19	. 13
80	. 83	. 37	. 76	. 15	. 61	. 48	. 39	. 31	. 22	. 15	. 10
90	. 52	. 23	. 48	. 09	. 38	. 30	. 24	. 20	. 14	. 09	. 06
Rad. T. E.	0. 18		0. 14		. 08	. 07	. 05	. 04	. 03	. 02	. 02
Rad. L. E.	. 64		. 30		. 11	. 09	. 07	. 06	. 04	. 03	. 02
Chord	6. 27		6. 54		7. 12	7. 25	7. 07	6. 45	5. 42	4. 05	3. 31

The chord is divided into 10 equal parts, or stations, with the one at the leading edge subdivided into halves and quarters. S equals stations in per cent of chord from the leading edge.

APPARATUS AND METHODS

The propellers used were of the detachable-blade type, having solid aluminum alloy blades held in a split steel hub. The blades of the 10.5-foot geared propeller were made according to the drawing in Figure 1 (Navy design No. 4102), and the blade form is given by the curves of Figure 2. The smaller direct-drive propeller, Figure 1a (Navy design No. 4412) was geometrically similar, but only 9 feet in diameter. The steel hub, in order to save weight, had been made 1 inch shorter than that for which the blades were designed, and so

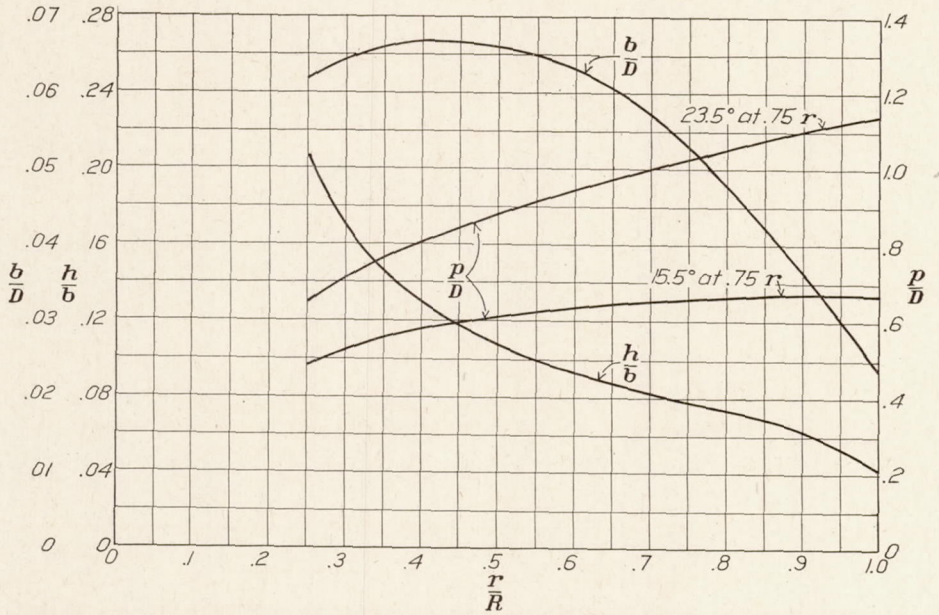

FIGURE 2.—No. 4412 and 4102 propeller blade form curves. D=diameter, b=blade width, h=blade thickness, p=pitch, R=tip radius=$D/2$, r=radius

the propellers as tested actually had diameters of 10 feet 5 inches, and 8 feet 11 inches. The propellers were tested at two pitch settings, 15.5° and 23.5° at three-fourths of the tip radius. The pitch distribution with each setting is shown in Figure 2.

The geared propeller was tested on a 9-cylinder, 200 horsepower Wright "Whirlwind" J–5 radial air-cooled engine with 2 to 1 reduction gearing. The direct-drive propeller was tested on a similar engine without the reduction gearing. One test was also made with the 10-foot 5-inch propeller directly driven.

The 8-foot 11-inch direct-drive propeller absorbed the full power of the engine at normal revolutions, but the 10-foot 5-inch propeller did not absorb the full power at normal engine revolutions as geared to run at one-half engine speed. The 10-foot 5-inch propeller is approximately the correct size for a gear reduction of 3 to 2 instead of 2 to 1. Since the propeller characteristics are given in terms of coefficients, the exact revolutions are unimportant, and the results should be taken as applying to a gear reduction of 3 to 2.

The fuselages are shown in Figures 3, 4, 5, and 6. With the geared engine the propeller was located 7.5 inches farther forward of the cylinders than with the direct-drive engine of the same model. The maximum cross-sectional area of the large fuselage was 21.3 square feet, and that of the open fuselage was 11 square feet, or approximately half as great. The engine, in both cases, was mounted on an inclosed dynamometer for measuring the torque of the propeller.

The propeller torque as measured included the torque on the cylinders due to the rotational velocity of the slip stream. In order to correct for this effect a special test was made in which three J–5 cylinders complete with valve gear were mounted under the front portion of a water-cooled Wright E–2 engine on a VE–7 fuselage in the Propeller Research Tunnel. (Fig. 7.) The cylinders were in the same position relative to the propeller as on a J–5 engine. The middle cylinder only was supported in such a way that its torque about the engine axis could be measured. The torque on the middle cylinder was then found for various engine and air speeds, and the results have been used to apply a correction to the propeller torque, amounting to less than 1 per cent in the case of the geared propeller, but as much as 3 per cent with the direct-drive propeller.

The resultant horizontal force of the propeller-body combination, which may be either a thrust or a drag,

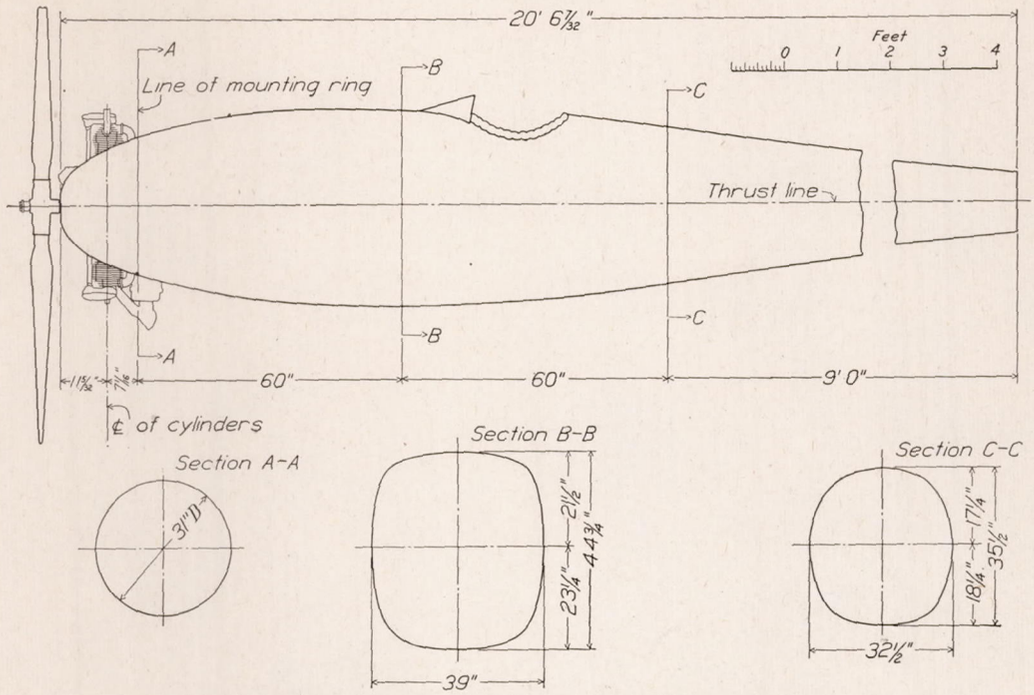

FIGURE 3.—Open cockpit fuselage with direct-drive J-5 engine

NOTE.—With geared engine, nose was pointed and propeller was 7½ inches farther forward

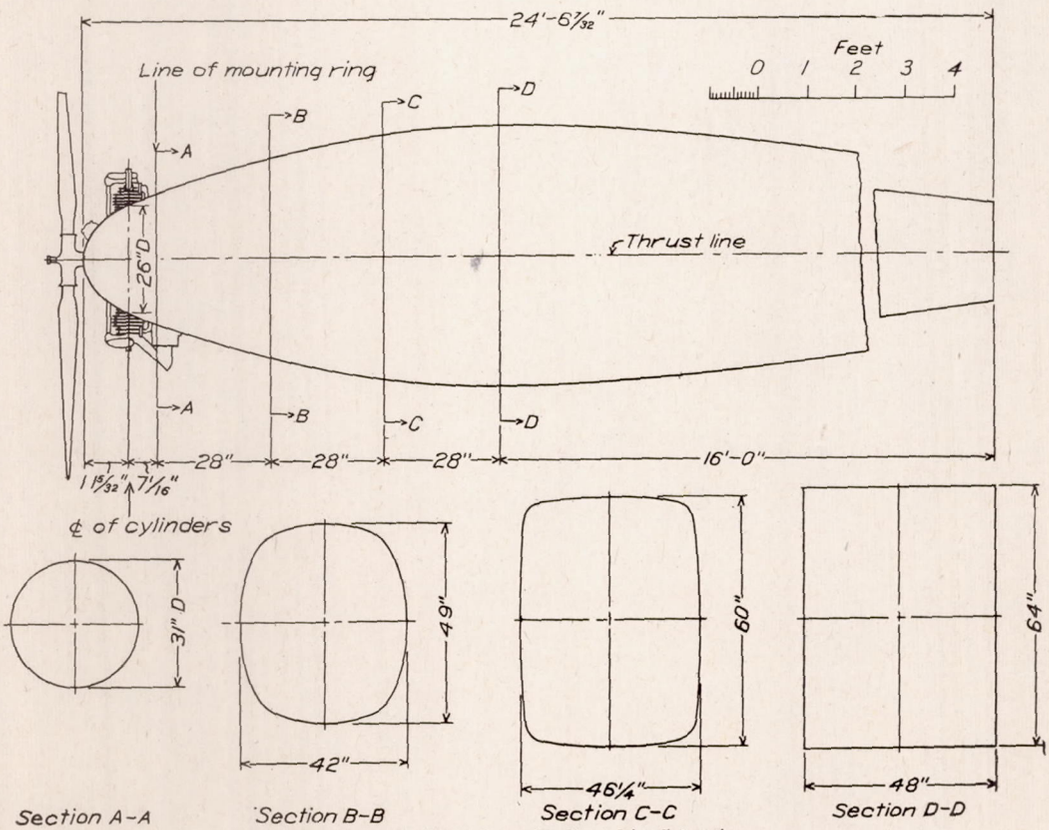

FIGURE 4.—Cabin fuselage with direct-drive J-5 engine

NOTE.—With geared engine, nose was pointed and propeller was 7½ inches farther forward

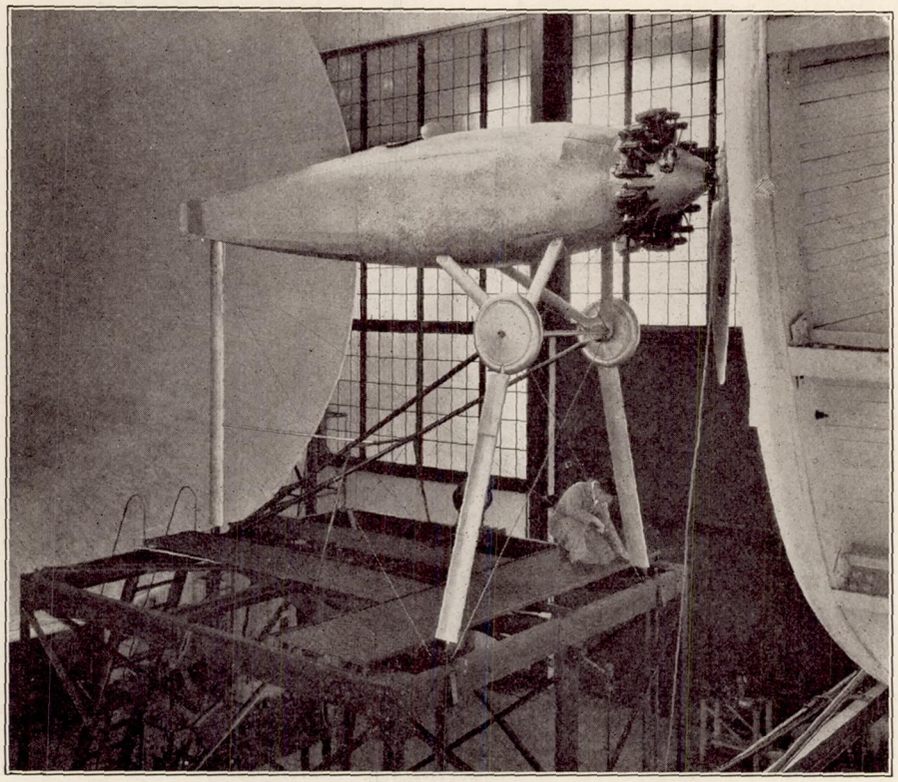

FIGURE 5.—Open cockpit fuselage with geared J–5 engine

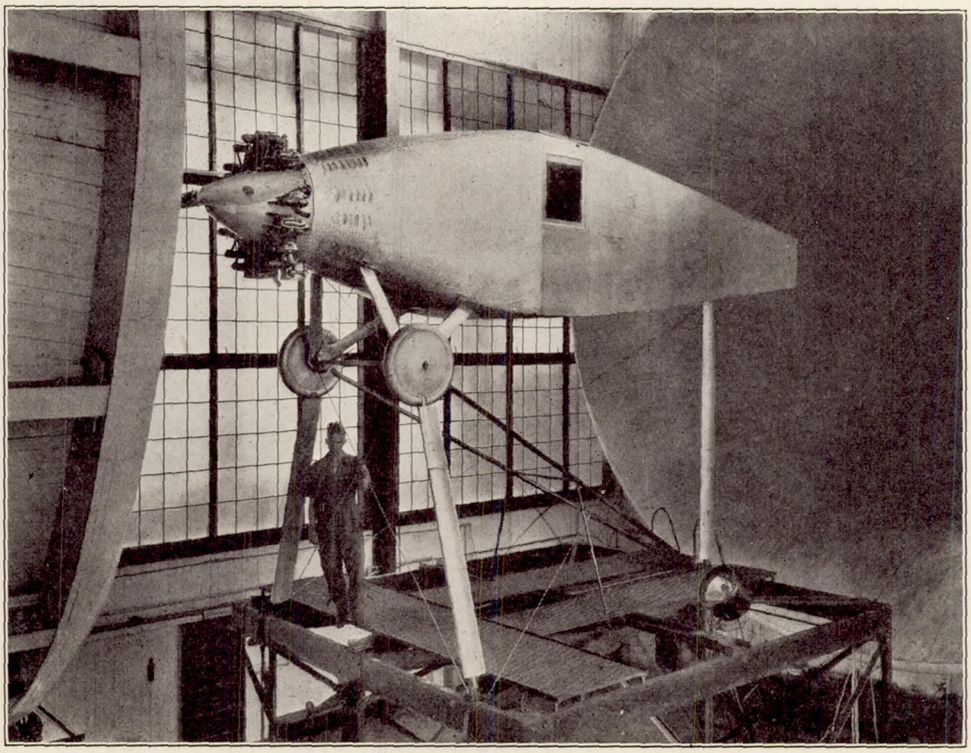

FIGURE 6.—Cabin fuselage J–5 engine

was measured on the regular thrust balance. (Reference 2.) This resultant horizontal force R, may be

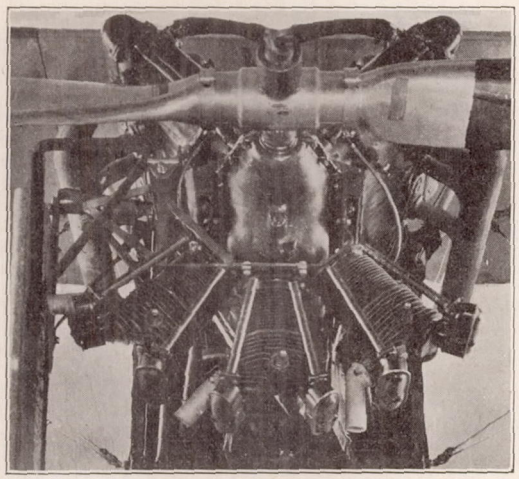

FIGURE 7.—J-5 cylinders mounted on E-2 engine for slip stream torque tests

thought of as being composed of three horizontal components, such that

$$R = T - D - \Delta D$$

where

T = the thrust of the propeller while operating in front of the body (the tension in the propeller shaft).

D = the drag of the airplane alone (without propeller) at the same air velocity and density.

ΔD = the increase of drag of the airplane with propeller, due to the slip stream.

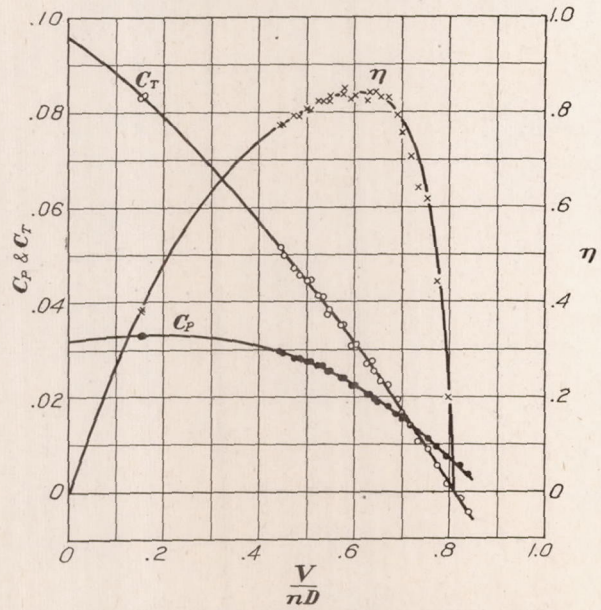

FIGURE 8.—Geared propeller No. 4102 (15.5° at 0.75 R). Diameter 10 feet 5 inches on open cockpit fuselage

In order to obtain the propulsive efficiency, an effective thrust is used which is defined as

$$\text{Effective thrust} = T - \Delta D = R + D.$$

The propulsive efficiency is then the ratio of the useful power to the input power, or

$$\text{Propulsive efficiency} = \frac{\text{effective thrust} \times \text{velocity of advance}}{\text{input power}}.$$

This includes the increase in drag of all parts of the airplane affected by the slip stream, and also the effect of the body interference on the propeller characteristics.

RESULTS

The observed data points for each of the four tests with the geared propeller and the five tests with the

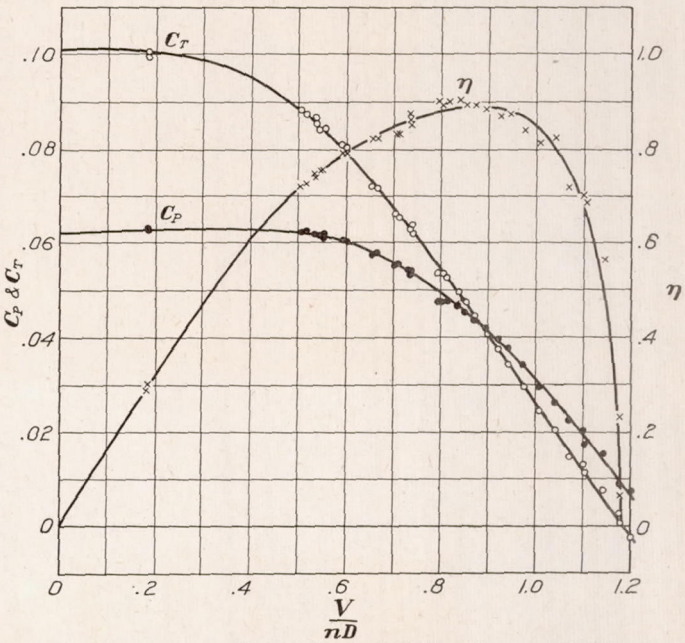

FIGURE 9.—Geared propeller No. 4102 (23.5° at 0.75 R). Diameter 10 feet 5 inches on open cockpit fuselage

direct-drive propellers are given in Figures 8 to 16 and in Table I. They are reduced to the usual coefficients of thrust, power, and propulsive efficiency.

$$C_T = \frac{\text{effective thrust}}{\rho n^2 D^4}$$

$$C_P = \frac{\text{input power}}{\rho n^3 D^5}$$

$$\eta = \frac{\text{effective thrust} \times \text{velocity of advance}}{\text{input power}}$$

where D is the propeller diameter and n represents the revolutions per unit time. Since the coefficients are dimensionless, any homogeneous system of units may be used.

The direct-drive and geared propellers are compared in Figures 17 and 18. The comparisons are made between geometrically similar propellers, so that the effect of body interference only is considered. (In a case where a geared propeller is substituted for a direct-drive propeller, both absorbing the same power at approximately the same forward speed, the pitch ratio of the geared-down propeller is, of course,

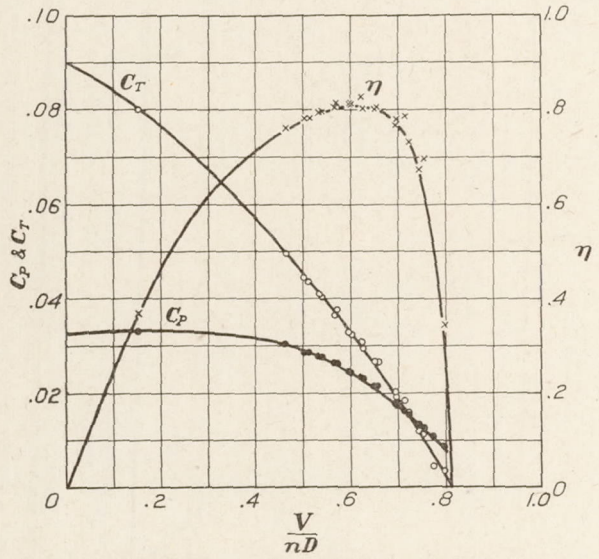

FIGURE 10.—Geared propeller No. 4102 (15.5° at 0.75 *R*). Diameter 10 feet 5 inches on cabin fuselage

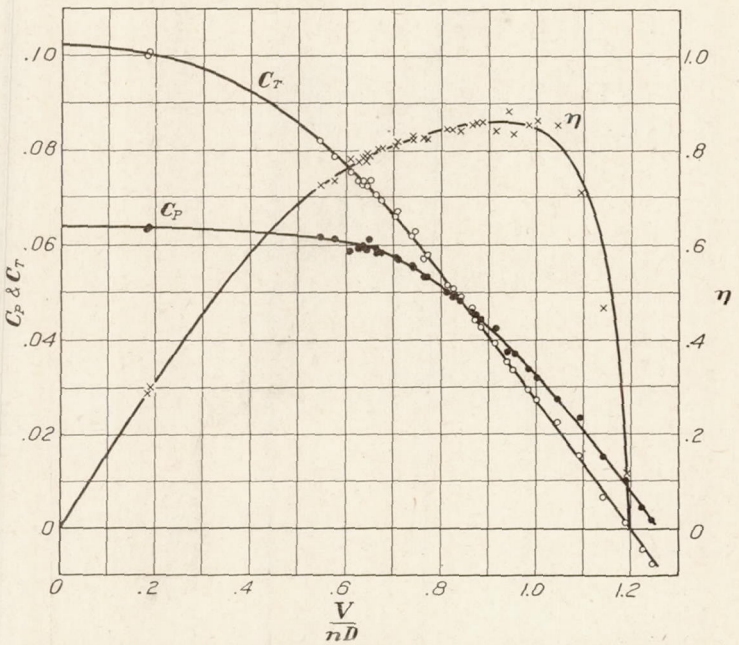

FIGURE 11.—Geared propeller No. 4102 (23.5° at 0.75 *R*). Diameter 10 feet 5 inches on cabin fuselage

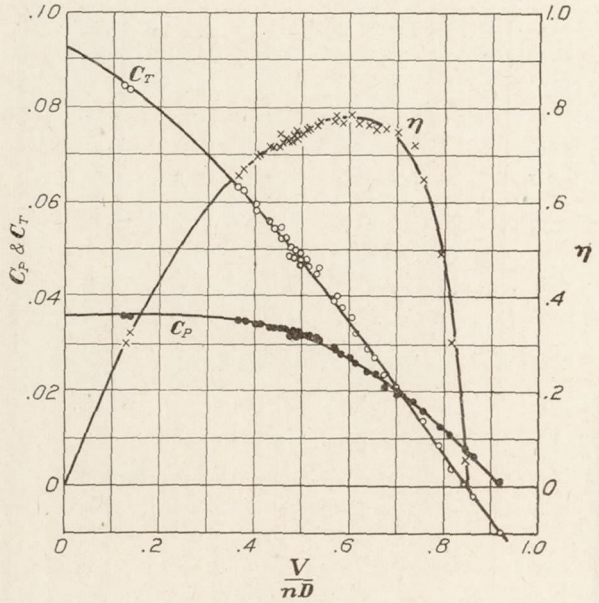

FIGURE 12.—Direct-drive propeller No. 4412 (15.5° at 0.75 *R*). Diameter 8 feet 11 inches on open cockpit fuselage

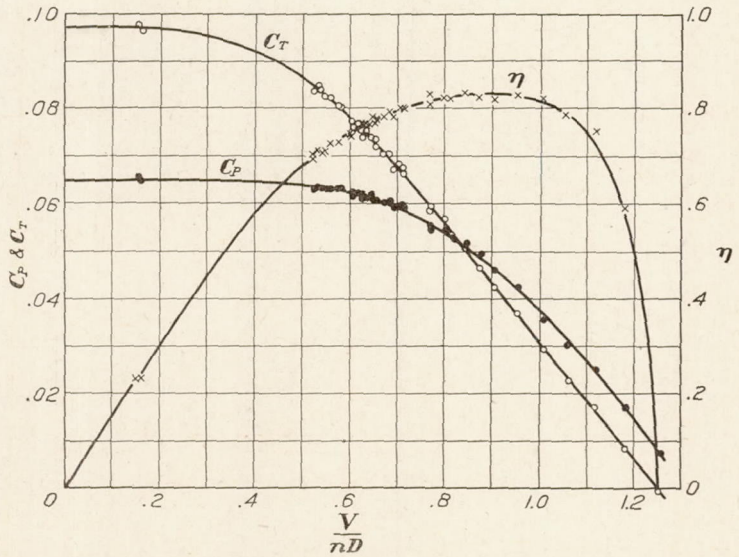

FIGURE 13.—Direct-drive propeller No. 4412 (23.5° at 0.75 *R*). Diameter 8 feet. 11 inches on open cockpit fuselage

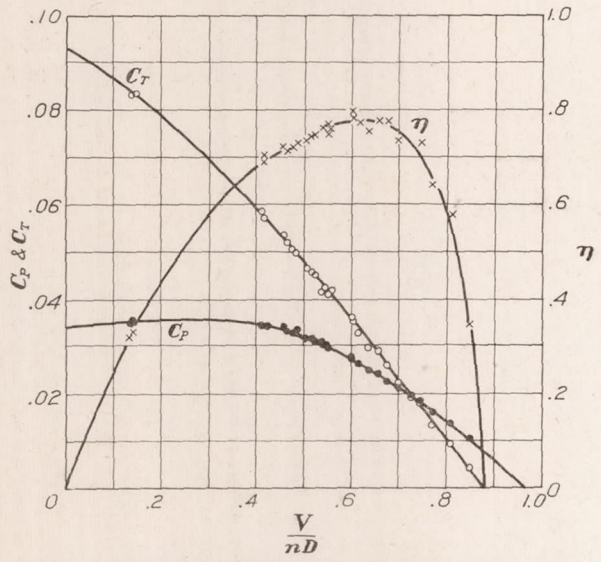

FIGURE 14.—Direct-drive propeller No. 4412 (15.5° at 0.75 R). Diameter 8 feet 11 inches on cabin fuselage

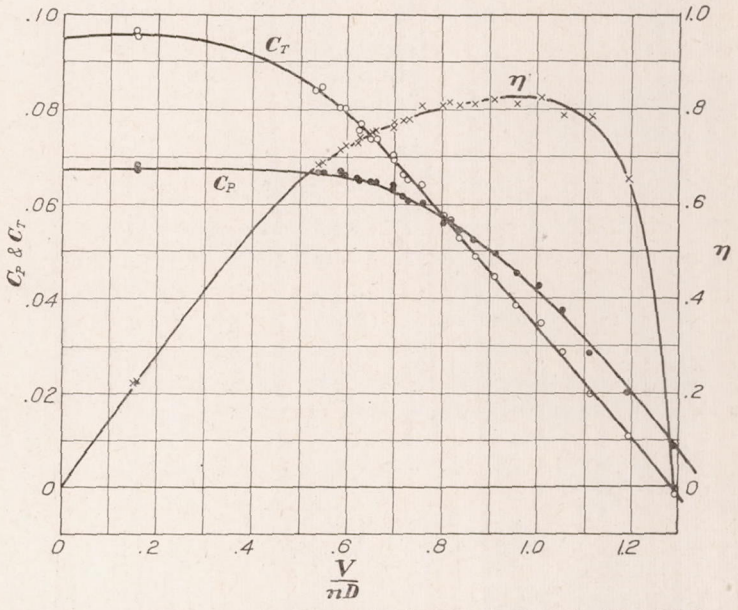

FIGURE 15.—Direct-drive propeller No. 4412 (23.5° at 0.75 R). Diameter 8 feet 11 inches on cabin fuselage

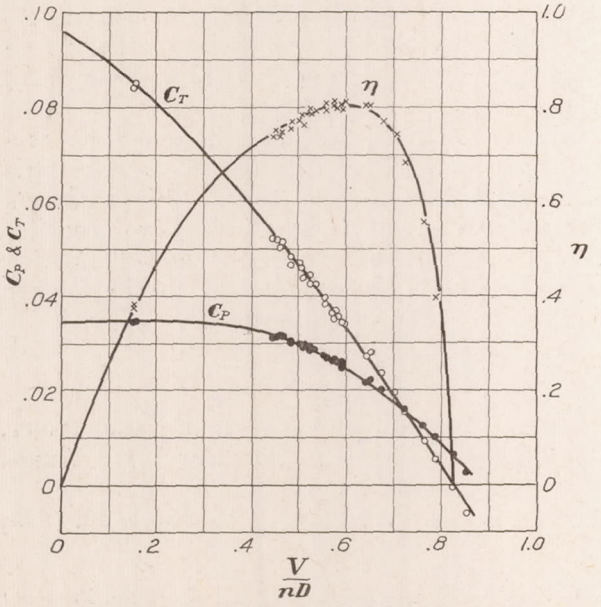

FIGURE 16.—Direct-drive propeller No. 4102 (15.5° at 0.75 R). Diameter 10 feet 5 inches on open cockpit fuselage

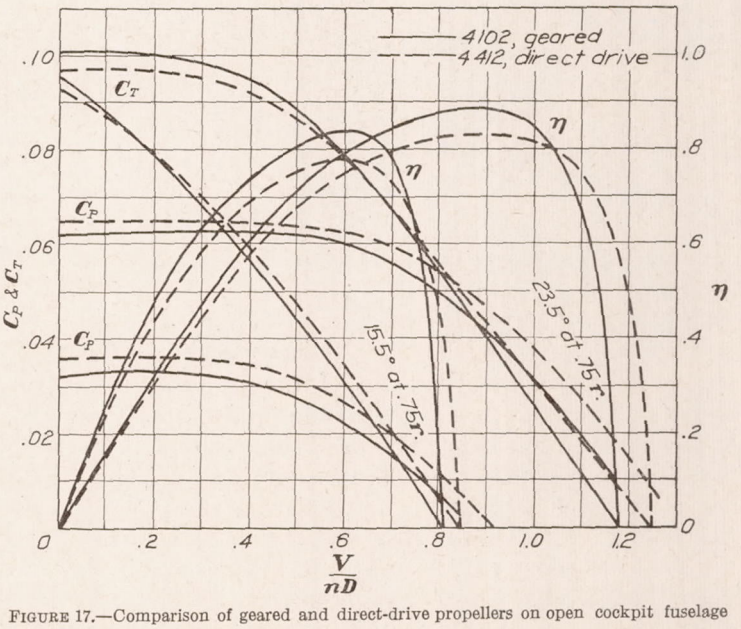

FIGURE 17.—Comparison of geared and direct-drive propellers on open cockpit fuselage

higher, which gives it an additional advantage in efficiency.)

DISCUSSION

With the small fuselage, the maximum efficiencies of the low and high pitch geared propellers were 7.5 per cent and 6.5 per cent higher, respectively, than the maximum efficiencies of the similar direct-drive propellers. With the large fuselage the maximum efficiencies of the geared propellers were 4 per cent and 3.5 per cent greater.

The value of $\frac{V}{nD}$ for zero thrust was about 5 per cent greater for the direct-drive than for the geared propellers with the small fuselage and about 8 per cent with the large fuselage. In all cases, the power and thrust coefficient curves were found to be higher for the direct-drive propellers than for the geared.

The 10-foot 5-inch propeller (No. 4102) which was used in the tests with the geared engine has also been tested on a similar direct-drive engine in the small fuselage. (Reference 3.) This test makes possible an

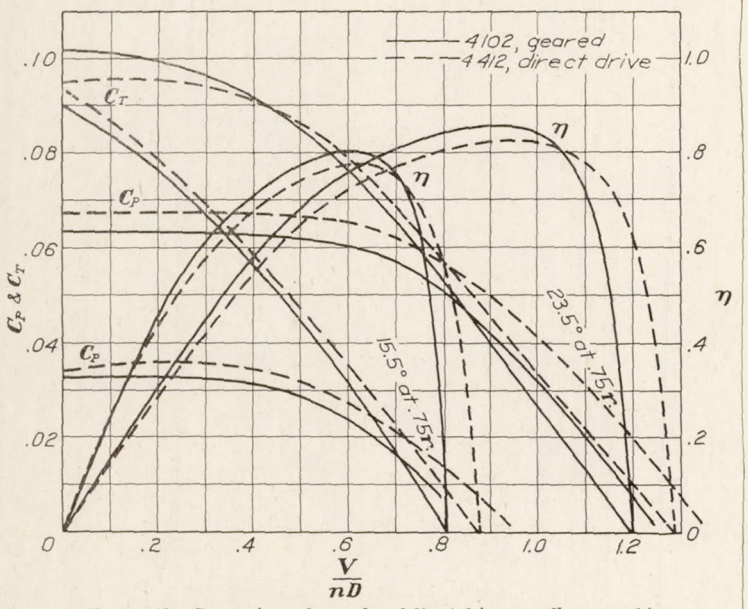

FIGURE 18.—Comparison of geared and direct-drive propellers on cabin fuselage

interesting comparison showing what part of the gain in efficiency with the geared propellers was due to the difference in the relative size of the propeller and body, and what part was due to the forward position of the geared propeller. The coefficiencts for the 10-foot 5-inch propeller, both geared and directly driven, are shown in Figure 19. The maximum efficiency of the geared propeller, which is 7.5 inches farther forward with respect to the engine, is 4 per cent higher than that of the direct-drive propeller. (This same effect could be obtained by lengthening the crank shaft and nose of the direct-drive engine.) Thus, of the total difference of 7.5 per cent between the maximum efficiencies of the 10-foot 5-inch geared propeller and the 8-foot 11-inch direct-drive propeller, about half is due to the larger diameter of the geared propeller and about half to its location farther forward.

It should be remembered that, although the actual gear ratio was 2 : 1, the 10-foot 5-inch propeller was not large enough to absorb the full engine power at that gear ratio, and the propeller-body interference effects shown by these tests are correct for a gear ratio of approximately 3 : 2.

CONCLUSIONS

1. The maximum efficiencies of the 10-foot 5-inch geared propellers of these tests were from 3.5 per cent

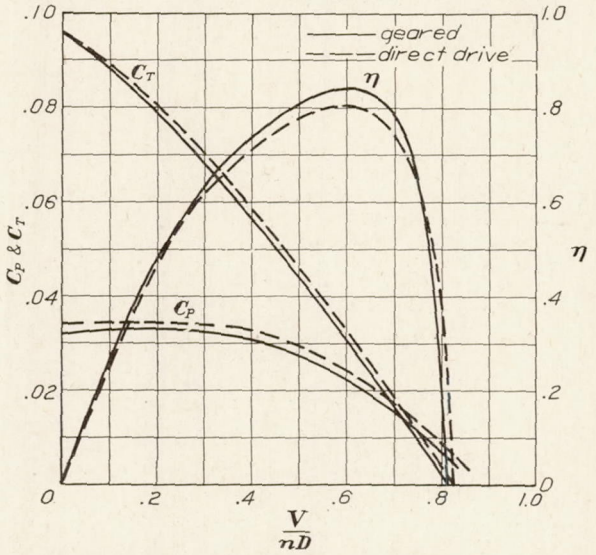

FIGURE 19.—Comparison of propeller No. 4102 (15.5° at 0.75 *R*). Diameter 10 feet 5 inches, geared and direct drive, on open cockpit fuselage

to 7.5 per cent greater than those of the similar 8-foot 11-inch direct-drive propellers, these differences representing the effect of propeller-body interference only.

2. The differences in the efficiencies of the geared and direct-drive propellers were greater with the small fuselage.

3. With the small fuselage and the low-pitch propellers, about half of the difference between the maximum efficiencies of the 10-foot 5-inch geared propeller and the 8-foot 11-inch direct-drive propeller was due to the relative sizes of the propellers with respect to the body, and about half to the farther forward position of the geared propeller.

LANGLEY MEMORIAL AERONAUTICAL LABORATORY,
NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS,
LANGLEY FIELD, VA., *March 20, 1929.*

REFERENCES

1. Weick, Fred E.: Full Scale Tests on a Thin Metal Propeller at Various Tip Speeds. N. A. C. A. Technical Report No. 302, 1928.
2. Weick, Fred E., and Wood, Donald H.: The Twenty-Foot Propeller Research Tunnel of the National Advisory Committee for Aeronautics. N. A. C. A. Technical Report No. 300, 1928.
3. Weick, Fred E.: Full Scale Tests with a Series of Propellers of Different Diameters on a Single Fuselage. N. A. C. A. Technical Report No. 339, 1929.

TABLE I

OBSERVED DATA

Geared Propeller No. 4102 (15.5° at 0.75 R)

Diameter, 10 feet 5 inches

On open cockpit fuselage

ρ	V m. p. h.	N r. p. m.	Q lb. ft.	T lb.	C_T	C_P	$\frac{V}{nD}$	η
0. 002288	83. 0	1, 115	316	252	0. 0270	0. 0205	0. 629	0. 828
. 002288	83. 6	1, 115	316	253	. 0272	. 0205	. 634	. 841
. 002288	83. 4	1, 090	285	224	. 0252	. 0193	. 645	. 841
. 002288	83. 2	1, 070	261	199	. 0232	. 0183	. 657	. 831
. 002288	82. 8	1, 040	243	182	. 0224	. 0181	. 673	. 831
. 002280	83. 0	1, 015	211	147	. 0191	. 0165	. 691	. 799
. 002280	82. 5	995	186	121	. 0164	. 0151	. 700	. 757
. 002280	82. 2	965	162	96	. 0138	. 0141	. 720	. 705
. 002280	82. 0	940	134	70	. 0106	. 0122	. 736	. 640
. 002280	81. 8	915	115	56	. 0089	. 0110	. 755	. 614
. 002280	81. 6	890	93	32	. 0054	. 0094	. 775	. 443
. 002280	81. 3	865	66	10	. 0017	. 0071	. 794	. 199
. 002280	81. 3	835	48	−6	−. 0011	. 0055	. 824	----
. 002280	81. 0	815	31	−23	−. 0046	. 0037	. 840	----
. 002280	78. 4	1, 110	339	284	. 0309	. 0222	. 596	. 830
. 002280	79. 2	1, 115	344	288	. 0310	. 0224	. 601	. 831
. 002283	75. 1	1, 100	361	317	. 0350	. 0240	. 576	. 840
. 002283	75. 4	1, 100	360	317	. 0350	. 0240	. 579	. 844
. 002283	71. 6	1, 100	378	344	. 0381	. 0252	. 550	. 831
. 002283	71. 5	1, 100	378	342	. 0378	. 0252	. 549	. 824
. 002283	68. 6	1, 100	397	373	. 0413	. 0264	. 527	. 825
. 002283	69. 4	1, 100	398	371	. 0410	. 0266	. 533	. 821
. 002286	65. 2	1, 100	416	404	. 0446	. 0277	. 501	. 806
. 002286	65. 6	1, 100	416	404	. 0446	. 0277	. 505	. 814
. 002286	62. 0	1, 105	425	430	. 0470	. 0281	. 474	. 792
. 002286	63. 0	1, 100	423	416	. 0459	. 0281	. 484	. 790
. 002286	58. 0	1, 100	441	466	. 0515	. 0296	. 446	. 776
. 002286	58. 2	1, 090	427	443	. 0499	. 0290	. 451	. 776
. 002286	19. 6	1, 100	491	749	. 0828	. 0327	. 150	. 382
. 002286	19. 9	1, 100	495	750	. 0830	. 0330	. 153	. 385

TABLE I—Continued

Geared propeller No. 4102 (23.5° at 0.75 R)

Diameter, 10 feet 5 inches

On open cockpit fuselage

ρ	V m. p. h.	N r. p. m.	Q lb. ft.	T lb.	C_T	C_P	$\frac{V}{nD}$	η
0. 002276	84. 9	1, 015	705	507	0. 0662	0. 0556	0. 705	0. 839
. 002276	85. 2	1, 015	705	502	. 0657	. 0556	. 710	. 838
. 002276	88. 7	1, 015	686	477	. 0624	. 0541	. 739	. 852
. 002276	88. 4	1, 015	688	484	. 0634	. 0543	. 737	. 858
. 002268	90. 9	1, 045	725	509	. 0628	. 0540	. 734	. 854
. 002268	90. 9	1, 050	720	512	. 0626	. 0532	. 732	. 862
. 002268	92. 0	1, 060	741	525	. 0629	. 0535	. 734	. 862
. 002268	92. 5	1, 060	741	529	. 0635	. 0535	. 738	. 874
. 002262	104. 4	1, 100	707	476	. 0533	. 0476	. 802	. 897
. 002262	103. 7	1, 100	707	483	. 0539	. 0476	. 796	. 900
. 002255	103. 8	1, 075	669	446	. 0525	. 0475	. 815	. 901
. 002255	103. 2	1, 040	611	397	. 0499	. 0463	. 840	. 905
. 002255	103. 3	1, 025	578	365	. 0474	. 0450	. 853	. 897
. 002255	102. 3	990	523	321	. 0444	. 0435	. 875	. 895
. 002255	102. 2	970	486	291	. 0420	. 0425	. 894	. 884
. 002255	102. 4	940	430	245	. 0377	. 0399	. 922	. 871
. 002255	102. 3	915	380	212	. 0345	. 0373	. 945	. 874
. 002255	101. 9	885	329	172	. 0298	. 0345	. 974	. 842
. 002255	101. 2	850	262	129	. 0242	. 0298	1. 009	. 817
. 002255	100. 9	820	214	102	. 0207	. 0261	1. 040	. 825
. 002250	101. 1	800	172	70	. 0148	. 0221	1. 070	. 720
. 002250	101. 1	775	130	49	. 0110	. 0177	1. 105	. 690
. 002250	101. 2	750	108	32	. 0077	. 0157	1. 141	. 564
. 002250	101. 1	725	57	2	. 0005	. 0089	1. 179	. 068
. 002256	79. 1	1, 015	723	546	. 0720	. 0577	. 658	. 821
. 002256	79. 8	1, 015	723	544	. 0717	. 0577	. 665	. 828
. 002352	81. 4	625	103	39	. 0130	. 0204	1. 100	. 700
. 002352	81. 5	585	51	6	. 0022	. 0117	1. 178	. 230
. 002352	81. 7	575	33	−6	−. 0023	. 0071	1. 200	----
. 002352	77. 0	1, 100	933	753	. 0810	. 0605	. 593	. 794
. 002352	77. 5	1, 100	933	749	. 0806	. 0605	. 596	. 794
. 002352	71. 4	1, 100	944	787	. 0840	. 0612	. 548	. 758
. 002352	71. 8	1, 100	941	781	. 0840	. 0610	. 551	. 758
. 002352	69. 8	1, 100	955	805	. 0865	. 0619	. 536	. 749
. 002352	69. 8	1, 100	954	799	. 0860	. 0619	. 536	. 745
. 002355	66. 0	1, 100	958	821	. 0885	. 0622	. 507	. 720
. 002355	67. 3	1, 100	958	811	. 0875	. 0622	. 516	. 725
. 002364	23. 7	1, 100	974	938	. 1005	. 0629	. 182	. 291
. 002364	24. 0	1, 100	968	932	. 0996	. 0625	. 185	. 295

TABLE I—Continued

Geared propeller No. 4102 (15.5° at 0.75 R)

Diameter, 10 feet 5 inches

On cabin fuselage

ρ	V m. p. h.	N r. p. m.	Q lb. ft.	T lb.	C_T	C_P	$\frac{V}{nD}$	η
0. 002324	80. 0	847	81	21	0. 0038	0. 0089	0. 798	0. 342
. 002324	80. 6	880	107	25	. 0042	. 0109	. 775	. 301
. 002324	81. 3	910	131	73	. 0116	. 0125	. 755	. 696
. 002316	81. 6	925	142	77	. 0119	. 0132	. 745	. 671
. 002316	82. 6	967	184	113	. 0159	. 0157	. 721	. 732
. 002316	82. 7	977	198	131	. 0181	. 0165	. 715	. 786
. 002316	83. 3	1, 012	227	154	. 0198	. 0177	. 695	. 778
. 002316	83. 3	1, 012	228	152	. 0196	. 0177	. 696	. 769
. 002316	77. 1	1, 002	268	200	. 0263	. 0213	. 651	. 805
. 002316	74. 5	1, 002	271	202	. 0266	. 0216	. 654	. 805
. 002312	74. 2	1, 002	292	226	. 0298	. 0233	. 626	. 800
. 002312	74. 0	1, 005	293	235	. 0308	. 0232	. 624	. 829
. 002312	71. 0	1, 002	302	248	. 0326	. 0240	. 600	. 815
. 002312	70. 6	1, 000	303	249	. 0329	. 0242	. 598	. 814
. 002312	67. 8	1, 002	329	282	. 0372	. 0262	. 571	. 811
. 002312	67. 8	1, 007	331	282	. 0368	. 0260	. 569	. 805
. 002315	64. 0	1, 007	352	311	. 0405	. 0276	. 540	. 793
. 002315	63. 8	1, 005	353	312	. 0409	. 0278	. 538	. 792
. 002315	60. 4	1, 000	356	328	. 0434	. 0284	. 512	. 782
. 002315	58. 8	995	356	334	. 0447	. 0287	. 501	. 781
. 002315	60. 4	1, 100	459	454	. 0496	. 0302	. 464	. 761
. 002324	15. 2	850	302	442	. 0805	. 0332	. 152	. 370

Geared propeller No. 4102 (23.5° at 0.75 R)

Diameter, 10 feet 5 inches

On cabin fuselage

ρ	V m. p. h.	N r. p. m.	Q lb. ft.	T lb.	C_T	C_P	$\frac{V}{nD}$	η
0. 002324	82. 1	557	7	−18	−0. 0076	0. 0017	1. 245	-----
. 002324	84. 5	1, 100	931	678	. 0736	. 0610	. 650	0. 785
. 002324	84. 0	1, 002	933	511	. 0669	. 0577	. 706	. 818
. 002324	84. 2	1, 007	738	512	. 0664	. 0575	. 706	. 815
. 002313	88. 8	1, 012	716	483	. 0623	. 0558	. 740	. 825
. 002313	88. 5	1, 010	715	483	. 0627	. 0559	. 740	. 830
. 002313	91. 4	1, 002	671	437	. 0575	. 0535	. 769	. 826
. 002313	91. 4	1, 005	674	439	. 0575	. 0534	. 766	. 825
. 002307	102. 9	1, 000	583	345	. 0458	. 0466	. 869	. 852
. 002307	102. 8	1, 002	588	352	. 0465	. 0470	. 865	. 855
. 002307	103. 1	1, 072	719	452	. 0520	. 0498	. 811	. 846
. 002300	102. 8	1, 055	687	426	. 0509	. 0496	. 824	. 844
. 002300	102. 8	1, 032	648	392	. 0489	. 0488	. 840	. 841
. 002300	102. 5	1, 000	573	340	. 0453	. 0459	. 866	. 855
. 002300	102. 5	980	530	311	. 0430	. 0442	. 885	. 860
. 002292	102. 4	945	470	263	. 0393	. 0425	. 915	. 846
. 002292	102. 1	920	393	224	. 0353	. 0374	. 940	. 888
. 002292	102. 1	910	387	206	. 0332	. 0377	. 950	. 836
. 002292	101. 9	875	321	169	. 0294	. 0339	. 984	. 853
. 002292	101. 8	860	295	153	. 0277	. 0320	1. 000	. 865
. 002292	101. 5	820	232	114	. 0226	. 0277	1. 046	. 854
. 002292	101. 3	785	178	70	. 0151	. 0233	1. 091	. 711
. 002292	101. 1	750	109	27	. 0064	. 0155	1. 140	. 470
. 002285	101. 1	720	67	4	. 0010	. 0104	1. 190	. 118
. 002285	101. 2	700	27	−17	−. 0046	. 0044	1. 222	----
. 002294	80. 2	1, 000	724	521	. 0695	. 0582	. 676	. 808
. 002294	80. 1	1, 000	725	519	. 0693	. 0581	. 676	. 805
. 002297	74. 4	945	650	472	. 0706	. 0586	. 665	. 801
. 002297	74. 6	950	652	476	. 0704	. 0580	. 665	. 806
. 002297	70. 6	930	634	469	. 0725	. 0590	. 642	. 789
. 002297	70. 6	930	634	471	. 0729	. 0590	. 642	. 793
. 002297	68. 2	900	599	441	. 0726	. 0598	. 640	. 778
. 002297	67. 6	900	599	447	. 0737	. 0598	. 635	. 782
. 002300	63. 2	877	563	435	. 0754	. 0585	. 609	. 785
. 002300	63. 2	857	541	407	. 0736	. 0592	. 624	. 775
. 002300	61. 5	905	628	484	. 0787	. 0615	. 574	. 735
. 002300	58. 1	902	628	501	. 0820	. 0618	. 545	. 724
. 002306	21. 6	980	762	730	. 1008	. 0635	. 187	. 297
. 002306	21. 0	980	758	726	. 1001	. 0630	. 181	. 288

TABLE I—Continued

Direct-Drive Propeller No. 4412 (15.5° at 0.75 R)

Diameter, 8 feet 11 inches

On open cockpit fuselage

ρ	V m. p. h.	N r. p. m.	Q lb. ft.	T lb.	C_T	C_P	$\frac{V}{nD}$	η
0. 002288	82. 1	1, 750	579	646	0. 0525	0. 0332	0. 464	0. 734
. 002280	82. 5	1, 710	542	591	. 0505	. 0327	. 476	. 735
. 002280	82. 8	1, 705	524	562	. 0484	. 0318	. 479	. 729
. 002272	82. 9	1, 690	519	555	. 0488	. 0322	. 484	. 734
. 002272	83. 8	1, 680	513	551	. 0490	. 0322	. 492	. 749
. 002272	82. 8	1, 685	516	556	. 0494	. 0322	. 485	. 744
. 002272	83. 5	1, 690	516	559	. 0492	. 0320	. 488	. 750
. 002269	88. 3	1, 750	550	582	. 0476	. 0318	. 498	. 746
. 002269	88. 0	1, 750	545	572	. 0469	. 0314	. 496	. 740
. 002269	90. 8	1, 765	561	586	. 0474	. 0319	. 509	. 755
. 002262	91. 1	1, 760	555	575	. 0468	. 0317	. 511	. 755
. 002259	94. 2	1, 750	547	558	. 0460	. 0318	. 531	. 770
. 002259	94. 2	1, 750	541	554	. 0452	. 0315	. 531	. 763
. 002256	104. 4	1, 810	529	511	. 0394	. 0290	. 570	. 775
. 002256	104. 1	1, 805	528	514	. 0398	. 0290	. 570	. 782
. 002256	103. 5	1, 750	485	457	. 0378	. 0282	. 584	. 769
. 002256	103. 5	1, 700	444	409	. 0358	. 0274	. 601	. 785
. 002256	103. 1	1, 650	396	350	. 0324	. 0260	. 616	. 769
. 002256	103. 0	1, 595	344	291	. 0289	. 0241	. 639	. 765
. 002248	102. 7	1, 550	318	261	. 0274	. 0236	. 653	. 758
. 002248	102. 4	1, 500	265	210	. 0236	. 0210	. 675	. 758
. 002248	103. 1	1, 455	233	175	. 0210	. 0196	. 700	. 748
. 002248	103. 5	1, 390	200	138	. 0181	. 0185	. 735	. 720
. 002248	103. 4	1, 355	165	100	. 0138	. 0160	. 754	. 650
. 002248	103. 1	1, 290	119	56	. 0085	. 0127	. 790	. 495
. 002248	102. 4	1, 240	87	23	. 0038	. 0101	. 815	. 306
. 002248	102. 8	1, 200	63	3	. 0005	. 0078	. 845	. 057
. 002248	102. 5	1, 100	7	−47	−. 0098	. 0010	. 920	----
. 002248	102. 5	1, 175	49	−11	−. 0020	. 0063	. 861	----
. 002258	80. 6	1, 760	579	666	. 0545	. 0332	. 453	. 744
. 002249	81. 5	1, 750	566	637	. 0525	. 0330	. 459	. 730
. 002252	78. 9	1, 705	538	599	. 0521	. 0330	. 456	. 720
. 002252	78. 9	1, 705	536	601	. 0524	. 0328	. 456	. 729
. 002252	74. 3	1, 705	549	645	. 0561	. 0336	. 430	. 719
. 002252	75. 7	1, 700	542	621	. 0545	. 0334	. 440	. 719
. 002255	68. 5	1, 675	540	655	. 0591	. 0344	. 404	. 695
. 002255	68. 2	1, 670	535	649	. 0589	. 0342	. 403	. 694
. 002255	61. 2	1, 660	541	688	. 0632	. 0350	. 364	. 656
. 002255	62. 8	1, 645	533	666	. 0624	. 0350	. 377	. 670
. 002264	20. 8	1, 600	519	859	. 0845	. 0360	. 1283	. 302
. 002264	22. 2	1, 590	511	838	. 0834	. 0358	. 1380	. 321

TABLE I—Continued

Direct-drive propeller No. 4412 (23.5° at 0.75 R)

Diameter, 8 feet 11 inches

On open cockpit fuselage

ρ	V m. p. h.	N r. p. m.	Q lb. ft.	T lb.	C_T	C_P	$\frac{V}{nD}$	η
0. 002294	84. 9	1, 290	583	494	0. 0738	0. 0614	0. 650	0. 783
. 002294	84. 9	1, 275	564	472	. 0722	. 0610	. 656	. 778
. 002287	88. 0	1, 290	575	473	. 0706	. 0606	. 674	. 785
. 002287	88. 7	1, 275	563	462	. 0709	. 0608	. 683	. 796
. 002287	91. 4	1, 295	567	454	. 0675	. 0595	. 696	. 790
. 002287	91. 7	1, 275	555	448	. 0686	. 0600	. 710	. 812
. 002284	93. 4	1, 300	576	461	. 0680	. 0600	. 710	. 805
. 002284	93. 6	1, 295	565	450	. 0670	. 0593	. 715	. 809
. 002281	105. 2	1, 350	575	430	. 0589	. 0555	. 770	. 818
. 002281	104. 6	1, 340	561	426	. 0592	. 0549	. 770	. 831
. 002273	104. 9	1, 295	519	378	. 0568	. 0549	. 800	. 829
. 002273	103. 5	1, 255	469	334	. 0533	. 0526	. 815	. 825
. 002273	103. 4	1, 210	429	299	. 0512	. 0518	. 844	. 835
. 002273	103. 4	1, 170	381	255	. 0467	. 0493	. 873	. 828
. 002273	102. 7	1, 120	329	211	. 0422	. 0463	. 904	. 824
. 002273	102. 7	1, 060	270	166	. 0371	. 0426	. 955	. 836
. 002273	102. 3	1, 000	203	117	. 0294	. 0359	1. 010	. 826
. 002265	102. 1	950	155	82	. 0228	. 0304	1. 060	. 795
. 002265	102. 1	900	115	55	. 0171	. 0252	1. 120	. 760
. 002265	101. 9	850	70	25	. 0086	. 0171	1. 182	. 559
. 002268	101. 9	800	28	−2	−. 0007	. 0077	1. 258	----
. 002274	83. 0	1, 295	585	501	. 0751	. 0616	. 633	. 771
. 002274	83. 2	1, 275	571	481	. 0742	. 0621	. 645	. 770
. 002274	79. 3	1, 270	567	495	. 0770	. 0623	. 616	. 763
. 002274	79. 2	1, 250	551	471	. 0755	. 0622	. 625	. 759
. 002274	79. 1	1, 245	539	460	. 0745	. 0615	. 629	. 761
. 002277	76. 2	1, 245	544	478	. 0774	. 0620	. 605	. 753
. 002277	76. 2	1, 240	537	467	. 0762	. 0619	. 606	. 746
. 002277	73. 1	1, 245	558	498	. 0805	. 0637	. 580	. 736
. 002277	72. 3	1, 235	546	489	. 0805	. 0633	. 578	. 735
. 002277	69. 4	1, 245	558	511	. 0826	. 0636	. 550	. 715
. 002277	69. 9	1, 230	543	499	. 0826	. 0634	. 560	. 731
. 002280	66. 4	1, 240	552	517	. 0842	. 0632	. 528	. 704
. 002280	67. 8	1, 225	539	495	. 0826	. 0635	. 546	. 711
. 002280	65. 5	1, 230	540	507	. 0838	. 0630	. 525	. 699
. 002280	65. 7	1, 215	533	501	. 0849	. 0638	. 530	. 705
. 002289	18. 8	1, 190	530	554	. 0975	. 0658	. 1561	. 232
. 002289	19. 2	1, 185	519	543	. 0963	. 0650	. 1600	. 237

TABLE I—Continued

Direct-drive propeller No. 4412 (15.5° at 0.75 R)

Diameter, 8 feet 11 inches,

On cabin fuselage

ρ	V m. p. h.	N r. p. m.	Q lb. ft.	T lb.	C_T	C_P	$\frac{V}{nD}$	η
0. 002236	86. 6	1, 655	478	490	0. 0457	0. 0315	0. 516	0. 749
. 002228	86. 6	1, 650	476	486	. 0456	. 0316	. 519	. 749
. 002225	89. 7	1, 645	452	449	. 0425	. 0300	. 539	. 763
. 002225	90. 0	1, 635	445	443	. 0424	. 0300	. 544	. 769
. 002225	93. 4	1, 670	467	455	. 0417	. 0302	. 552	. 763
. 002225	93. 0	1, 670	465	448	. 0411	. 0300	. 550	. 753
. 002222	103. 3	1, 700	440	407	. 0361	. 0275	. 601	. 789
. 002214	103. 2	1, 700	440	409	. 0365	. 0276	. 600	. 794
. 002214	103. 1	1, 655	392	349	. 0328	. 0260	. 615	. 775
. 002214	102. 5	1, 600	351	297	. 0299	. 0249	. 634	. 759
. 002214	102. 6	1, 545	320	269	. 0290	. 0244	. 655	. 780
. 002214	102. 8	1, 505	281	229	. 0260	. 0225	. 675	. 779
. 002214	102. 6	1, 450	248	185	. 0227	. 0214	. 698	. 739
. 002214	102. 5	1, 390	204	143	. 0190	. 0191	. 729	. 725
. 002214	102. 9	1, 355	187	129	. 0181	. 0185	. 749	. 732
. 002214	102. 2	1, 315	151	89	. 0133	. 0159	. 769	. 642
. 002214	102. 2	1, 255	117	59	. 0096	. 0135	. 805	. 575
. 002214	102. 2	1, 190	80	23	. 0041	. 0102	. 849	. 347
. 002220	84. 5	1, 650	478	491	. 0462	. 0317	. 505	. 736
. 002220	83. 9	1, 640	472	489	. 0466	. 0318	. 505	. 740
. 002224	80. 2	1, 640	492	524	. 0498	. 0331	. 483	. 726
. 002224	78. 6	1, 630	483	520	. 0501	. 0329	. 477	. 726
. 002226	74. 2	1, 590	469	515	. 0521	. 0335	. 461	. 717
. 002226	71. 9	1, 560	461	516	. 0543	. 0342	. 455	. 722
. 002230	64. 8	1, 540	452	531	. 0574	. 0344	. 415	. 691
. 002230	63. 7	1, 525	442	530	. 0583	. 0342	. 413	. 705
. 002236	21. 1	1, 515	455	748	. 0834	. 0358	. 137	. 321
. 002236	21. 1	1, 495	438	731	. 0835	. 0352	. 139	. 330

Direct-drive propeller No. 4412 (23.5° at 0.75 R)

Diameter, 8 feet 11 inches

On cabin fuselage

ρ	V m. p. h.	N r. p. m.	Q lb. ft.	T lb.	C_T	C_P	$\frac{V}{nD}$	η
0. 002239	87. 4	1, 185	476	359	0. 0652	0. 0608	0. 728	0. 780
. 002231	86. 0	1, 180	472	360	. 0661	. 0611	. 719	. 778
. 002228	92. 7	1, 205	485	363	. 0640	. 0602	. 759	. 808
. 002228	92. 1	1, 205	485	359	. 0632	. 0602	. 761	. 799
. 002225	103. 0	1, 270	499	356	. 0565	. 0558	. 801	. 810
. 002225	103. 5	1, 255	493	348	. 0566	. 0566	. 814	. 814
. 002225	102. 5	1, 215	447	304	. 0528	. 0547	. 833	. 804
. 002225	102. 9	1, 170	395	261	. 0488	. 0521	. 868	. 813
. 002225	102. 8	1, 115	338	215	. 0443	. 0491	. 910	. 821
. 002225	101. 9	1, 050	275	165	. 0384	. 0451	. 958	. 816
. 002225	101. 9	1, 000	236	136	. 0349	. 0427	1. 006	. 822
. 002225	101. 6	950	187	99	. 0281	. 0375	1. 054	. 790
. 002225	101. 4	900	126	63	. 0199	. 0282	1. 112	. 785
. 002225	101. 6	840	78	30	. 0109	. 0199	1. 194	. 652
. 002225	100. 8	770	27	−4	−. 0017	. 0082	1. 294	----
. 002224	84. 3	1, 200	503	391	. 0696	. 0631	. 694	. 766
. 002224	83. 6	1, 190	497	391	. 0707	. 0634	. 694	. 774
. 002227	78. 6	1, 180	497	404	. 0743	. 0644	. 658	. 759
. 002227	78. 2	1, 170	498	396	. 0740	. 0645	. 659	. 756
. 002227	73. 8	1, 165	487	408	. 0768	. 0648	. 625	. 741
. 002235	73. 6	1, 160	484	399	. 0756	. 0647	. 624	. 730
. 002237	67. 7	1, 135	477	409	. 0809	. 0664	. 588	. 716
. 002237	68. 0	1, 130	467	402	. 0803	. 0657	. 592	. 723
. 002237	61. 5	1, 120	463	415	. 0843	. 0663	. 542	. 689
. 002237	61. 0	1, 120	462	414	. 0841	. 0662	. 538	. 684
. 002246	17. 4	1, 100	460	459	. 0962	. 0679	. 1564	. 221
. 002246	17. 2	1, 085	443	445	. 0960	. 0673	. 1568	. 224

TABLE I—Continued

Direct-drive propeller No. 4102 (15.5° at 0.75 R)

Diameter, 10 feet 5 inches

On open cockpit fuselage

ρ	V m. p. h.	N r. p. m.	Q lb. ft.	T lb.	C_T	C_P	$\frac{V}{nD}$	η
0. 002224	85. 2	1, 295	555	484	0. 0397	0. 0274	0. 556	0. 806
. 002224	85. 2	1, 290	543	464	. 0383	. 0270	. 558	. 791
. 002224	88. 0	1, 295	529	450	. 0369	. 0261	. 575	. 811
. 002224	87. 8	1, 295	525	444	. 0364	. 0260	. 573	. 804
. 002224	89. 6	1, 305	535	444	. 0358	. 0260	. 580	. 800
. 002224	90. 0	1, 300	529	440	. 0358	. 0260	. 585	. 806
. 002220	93. 2	1, 320	528	434	. 0343	. 0252	. 596	. 811
. 002220	92. 4	1, 320	523	425	. 0336	. 0249	. 591	. 797
. 002217	105. 1	1, 370	501	373	. 0275	. 0223	. 650	. 802
. 002217	104. 5	1, 370	497	372	. 0274	. 0220	. 645	. 805
. 002217	104. 5	1, 310	418	288	. 0232	. 0203	. 675	. 771
. 002209	104. 1	1, 245	341	217	. 0194	. 0183	. 706	. 745
. 002209	103. 6	1, 205	279	159	. 0151	. 0160	. 725	. 683
. 002209	102. 9	1, 140	196	86	. 0091	. 0126	. 762	. 555
. 002209	102. 9	1, 100	148	45	. 0051	. 0102	. 790	. 398
. 002209	102. 5	1, 050	88	−5	−. 0006	. 0066	. 825	----
. 002209	102. 1	1, 010	32	−46	−. 0062	. 0026	. 855	----
. 002218	81. 6	1, 315	590	535	. 0427	. 0284	. 525	. 790
. 002218	82. 2	1, 295	576	515	. 0425	. 0286	. 536	. 796
. 002218	77. 4	1, 280	571	518	. 0437	. 0291	. 510	. 766
. 002218	77. 8	1, 250	555	505	. 0447	. 0296	. 526	. 795
. 002223	73. 3	1, 235	559	523	. 0470	. 0304	. 501	. 775
. 002223	73. 8	1, 230	549	511	. 0464	. 0300	. 507	. 785
. 002223	70. 9	1, 230	554	530	. 0480	. 0303	. 486	. 770
. 002223	70. 4	1, 230	547	515	. 0466	. 0299	. 484	. 754
. 002223	65. 6	1, 195	545	531	. 0511	. 0317	. 465	. 749
. 002223	65. 2	1, 195	539	523	. 0504	. 0313	. 461	. 741
. 002225	62. 6	1, 185	534	533	. 0521	. 0314	. 446	. 740
. 002225	63. 2	1, 180	529	527	. 0519	. 0314	. 454	. 750
. 002230	19. 0	1, 060	472	696	. 0850	. 0347	. 152	. 372
. 002230	19. 0	1, 060	468	690	. 0841	. 0344	. 152	. 372

TABLE II

FINAL ADJUSTED COEFFICIENTS

Geared propeller No. 4102 (15.5° at 0.75 R)

Diameter, 10 feet 5 inches

On open cockpit fuselage

$\frac{V}{nD}$	C_T	C_P	η	C_S
0. 10	0. 0880	0. 0328	0. 268	0. 198
. 15	. 0833	. 0330	. 378	. 296
. 20	. 0788	. 0329	. 479	. 396
. 25	. 0738	. 0328	. 562	. 495
. 30	. 0680	. 0322	. 633	. 596
. 35	. 0625	. 0319	. 686	. 697
. 40	. 0564	. 0308	. 732	. 801
. 45	. 0500	. 0292	. 771	. 912
. 50	. 0442	. 0274	. 807	1. 025
. 55	. 0380	. 0252	. 830	1. 148
. 60	. 0314	. 0224	. 840	1. 281
. 65	. 0246	. 0192	. 832	1. 432
. 70	. 0170	. 0152	. 781	1. 616
. 75	. 0100	. 0115	. 650	1. 832

TABLE II—Continued

Geared propeller No. 4102 (23.5° at 0.75 R)

Diameter, 10 feet 5 inches

On open cockpit fuselage

$\frac{V}{nD}$	C_T	C_P	η	C_S
0. 10	0. 1010	0. 0624	0. 162	0. 1742
. 15	. 1007	. 0627	. 241	. 262
. 20	. 1001	. 0628	. 319	. 348
. 25	. 0993	. 0629	. 395	. 435
. 30	. 0984	. 0628	. 470	. 521
. 35	. 0970	. 0627	. 541	. 610
. 40	. 0950	. 0624	. 610	. 697
. 45	. 0920	. 0622	. 665	. 785
. 50	. 0886	. 0620	. 715	. 872
. 55	. 0845	. 0614	. 757	. 961
. 60	. 0795	. 0602	. 791	1. 052
. 65	. 0736	. 0583	. 821	1. 147
. 70	. 0675	. 0560	. 844	1. 246
. 75	. 0611	. 0530	. 865	1. 351
. 80	. 0544	. 0494	. 880	1. 460
. 85	. 0479	. 0457	. 890	1. 578
. 90	. 0409	. 0414	. 889	1. 701
. 95	. 0338	. 0365	. 880	1. 850
1. 00	. 0265	. 0312	. 849	2. 00
1. 05	. 0192	. 0255	. 790	2. 19
1. 10	. 0120	. 0193	. 684	2. 42
1. 15	. 0051	. 0130	. 451	2. 74

TABLE II—Continued

Geared propeller No. 4102 (15.5° at 0.75 R)

Diameter, 10 feet 5 inches

On cabin fuselage

$\frac{V}{nD}$	C_T	C_P	η	C_S
0. 10	0. 0841	0. 0332	0. 254	0. 1974
. 15	. 0809	. 0333	. 364	. 296
. 20	. 0770	. 0332	. 464	. 395
. 25	. 0725	. 0330	. 549	. 493
. 30	. 0678	. 0329	. 618	. 594
. 35	. 0625	. 0326	. 670	. 695
. 40	. 0570	. 0320	. 712	. 795
. 45	. 0511	. 0308	. 746	. 903
. 50	. 0450	. 0290	. 775	1. 014
. 55	. 0390	. 0270	. 795	1. 130
. 60	. 0329	. 0245	. 806	1. 261
. 65	. 0260	. 0211	. 802	1. 406
. 70	. 0189	. 0172	. 770	1. 580
. 75	. 0111	. 0128	. 650	1. 795
. 80	. 0027	. 0080	. 270	2. 10

Geared propeller No. 4102 (23.5° at 0.75 R)

Diameter, 10 feet 5 inches

On cabin fuselage

$\frac{V}{nD}$	C_T	C_P	η	C_S
0. 10	0. 1016	0. 0638	0. 159	0. 1733
. 15	. 1009	. 0635	. 238	. 260
. 20	. 1000	. 0634	. 316	. 347
. 25	. 0989	. 0632	. 391	. 434
. 30	. 0970	. 0630	. 462	. 522
. 35	. 0949	. 0629	. 528	. 609
. 40	. 0921	. 0627	. 587	. 697
. 45	. 0890	. 0622	. 644	. 785
. 50	. 0856	. 0620	. 690	. 873
. 55	. 0819	. 0618	. 729	. 960
. 60	. 0771	. 0608	. 761	1. 050
. 65	. 0720	. 0593	. 790	1. 144
. 70	. 0666	. 0576	. 810	1. 239
. 75	. 0605	. 0546	. 829	1. 342
. 80	. 0540	. 0514	. 840	1. 450
. 85	. 0476	. 0475	. 853	1. 563
. 90	. 0408	. 0426	. 860	1. 691
. 95	. 0340	. 0375	. 860	1. 832
1. 00	. 0272	. 0321	. 850	1. 988
1. 05	. 0204	. 0264	. 810	2. 17
1. 10	. 0138	. 0208	. 730	2. 38
1. 15	. 0070	. 0145	. 555	2. 68

TABLE II—Continued

Direct-drive propeller No. 4412 (15.5° at 0.75 R)

Diameter, 8 feet 11 inches

On open cockpit fuselage

$\frac{V}{nD}$	C_T	C_P	η	C_S
0. 10	0. 0864	0. 0360	0. 240	0. 1945
. 15	. 0829	. 0360	. 346	. 292
. 20	. 0789	. 0360	. 438	. 389
. 25	. 0746	. 0360	. 518	. 486
. 30	. 0698	. 0359	. 582	. 584
. 35	. 0649	. 0352	. 645	. 682
. 40	. 0591	. 0342	. 690	. 785
. 45	. 0539	. 0335	. 723	. 886
. 50	. 0478	. 0318	. 751	. 996
. 55	. 0412	. 0294	. 770	1. 112
. 60	. 0360	. 0270	. 778	1. 232
. 65	. 0279	. 0236	. 770	1. 376
. 70	. 0210	. 0199	. 739	1. 531
. 75	. 0140	. 0160	. 656	1. 711
. 80	. 0070	. 0119	. 471	1. 941

Direct-drive propeller No. 4412 (23.5° at 0.75 R)

Diameter, 8 feet 11 inches

On open cockpit fuselage

$\frac{V}{nD}$	C_T	C_P	η	C_S
0. 10	0. 0971	0. 0650	0. 149	0. 1726
. 15	. 0970	. 0650	. 224	. 259
. 20	. 0969	. 0649	. 298	. 345
. 25	. 0960	. 0648	. 370	. 432
. 30	. 0953	. 0647	. 441	. 519
. 35	. 0941	. 0644	. 511	. 605
. 40	. 0921	. 0642	. 575	. 692
. 45	. 0898	. 0640	. 631	. 779
. 50	. 0867	. 0638	. 679	. 865
. 55	. 0830	. 0632	. 722	. 955
. 60	. 0781	. 0624	. 751	1. 046
. 65	. 0738	. 0616	. 776	1. 138
. 70	. 0682	. 0598	. 799	1. 230
. 75	. 0620	. 0570	. 816	1. 332
. 80	. 0559	. 0541	. 825	1. 432
. 85	. 0496	. 0507	. 831	1. 546
. 90	. 0433	. 0469	. 832	1. 660
. 95	. 0373	. 0427	. 829	1. 785
1. 00	. 0311	. 0380	. 818	1. 922
1. 05	. 0248	. 0327	. 797	2. 08
1. 10	. 0185	. 0270	. 754	2. 26
1. 15	. 0123	. 0211	. 670	2. 49
1. 20	. 0063	. 0150	. 505	2. 78

TABLE II—Continued

Direct-drive propeller No. 4412 (15.5° at 0.75 R)

Diameter, 8 feet 11 inches

On cabin fuselage

$\frac{V}{nD}$	C_T	C_P	η	C_S
0. 10	0. 0864	0. 0352	0. 245	0. 1953
. 15	. 0829	. 0357	. 348	. 292
. 20	. 0789	. 0360	. 438	. 389
. 25	. 0734	. 0360	. 510	. 486
. 30	. 0697	. 0359	. 583	. 584
. 35	. 0642	. 0353	. 636	. 683
. 40	. 0591	. 0349	. 677	. 783
. 45	. 0538	. 0339	. 714	. 885
. 50	. 0476	. 0322	. 740	. 994
. 55	. 0419	. 0302	. 762	1. 108
. 60	. 0359	. 0276	. 778	1. 230
. 65	. 0297	. 0248	. 779	1. 361
. 70	. 0228	. 0212	. 751	1. 513
. 75	. 0257	. 0177	. 696	1. 681
. 80	. 0101	. 0139	. 580	1. 882
. 85	. 00400	. 0100	. 340	2. 14

Direct-drive propeller No. 4412 (23.5° at 0.75 R)

Diameter, 8 feet 11 inches

On cabin fuselage

$\frac{V}{nD}$	C_T	C_P	η	C_S
0. 10	0. 0960	0. 0676	0. 142	0. 1715
. 15	. 0960	. 0678	. 213	. 257
. 20	. 0959	. 0678	. 283	. 343
. 25	. 0952	. 0676	. 352	. 428
. 30	. 0945	. 0674	. 421	. 515
. 35	. 0932	. 0673	. 484	. 601
. 40	. 0916	. 0671	. 546	. 686
. 45	. 0895	. 0670	. 600	. 772
. 50	. 0869	. 0668	. 651	. 859
. 55	. 0833	. 0662	. 692	. 947
. 60	. 0792	. 0658	. 722	1. 034
. 65	. 0746	. 0644	. 753	1. 125
. 70	. 0691	. 0627	. 771	1. 218
. 75	. 0635	. 0602	. 792	1. 316
. 80	. 0577	. 0572	. 807	1. 418
. 85	. 0519	. 0539	. 818	1. 524
. 90	. 0460	. 0500	. 827	1. 640
. 95	. 0400	. 0459	. 829	1. 760
1. 00	. 0340	. 0412	. 823	1. 892
1. 05	. 0281	. 0364	. 810	2. 04
1. 10	. 0220	. 0310	. 780	2. 20
1. 15	. 0164	. 0258	. 732	2. 39
1. 20	. 0106	. 0202	. 630	2. 68
1. 25	. 0045	. 0140	. 402	2. 94

TABLE II—Continued

Direct-drive propeller No. 4102 (15.5° at 0.75 R)

Diameter, 10 feet 5 inches

On open cockpit fuselage

$\frac{V}{nD}$	C_T	C_P	η	C_S
0. 10	0. 0890	0. 0345	0. 258	0. 1960
. 15	. 0850	. 0344	. 370	. 294
. 20	. 0805	. 0342	. 470	. 393
. 25	. 0758	. 0340	. 556	. 492
. 30	. 0701	. 0340	. 619	. 591
. 35	. 0646	. 0338	. 670	. 690
. 40	. 0588	. 0330	. 712	. 790
. 45	. 0527	. 0317	. 748	. 896
. 50	. 0465	. 0299	. 778	1. 008
. 55	. 0400	. 0275	. 799	1. 128
. 60	. 0332	. 0247	. 806	1. 257
. 65	. 0263	. 0216	. 791	1. 394
. 70	. 0191	. 0180	. 743	1. 563
. 75	. 0118	. 0138	. 640	1. 765
. 80	. 0042	. 0091	. 370	2. 05

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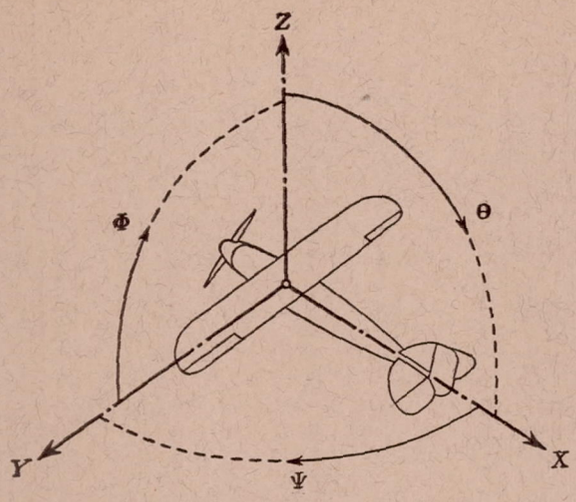

Positive directions of axes and angles (forces and moments) are shown by arrows

Axis		Force (parallel to axis) symbol	Moment about axis			Angle		Velocities	
Designation	Symbol		Designation	Symbol	Positive direction	Designation	Symbol	Linear (component along axis)	Angular
Longitudinal	X	X	rolling	L	$Y \longrightarrow Z$	roll	Φ	u	p
Lateral	Y	Y	pitching	M	$Z \longrightarrow X$	pitch	Θ	v	q
Normal	Z	Z	yawing	N	$X \longrightarrow Y$	yaw	Ψ	w	r

Absolute coefficients of moment

$$C_L = \frac{L}{qbS} \qquad C_M = \frac{M}{qcS} \qquad C_N = \frac{N}{qfS}$$

Angle of set of control surface (relative to neutral position), δ. (Indicate surface by proper subscript.)

4. PROPELLER SYMBOLS

D, Diameter.
p_e, Effective pitch.
p_g, Mean geometric pitch.
p_s, Standard pitch.
p_v, Zero thrust.
p_a, Zero torque.
p/D, Pitch ratio.
V', Inflow velocity.
V_s, Slip stream velocity.

T, Thrust.
Q, Torque.
P, Power.
(If "coefficients" are introduced all units used must be consistent.)
η, Efficiency $= T\ V/P$.
n, Revolutions per sec., r. p. s.
N, Revolutions per minute, r. p. m.
Φ, Effective helix angle $= \tan^{-1}\left(\frac{V}{2\pi rn}\right)$

5. NUMERICAL RELATIONS

1 hp = 76.04 kg/m/s = 550 lb./ft./sec.
1 kg/m/s = 0.01315 hp
1 mi./hr. = 0.44704 m/s
1 m/s = 2.23693 mi./hr.

1 lb. = 0.4535924277 kg
1 kg = 2.2046224 lb.
1 mi. = 1609.35 m = 5280 ft.
1 m = 3.2808333 ft.